Listing of Claims:

1. (Currently Amended) A sequential resonant tunneling p-i-n device for use as a photodetector or optically pumped emitter, said sequential resonant tunneling device comprising:

a) a substrate, which is crystal lattice-matched to at least one III-nitride material;

b) a p type semiconductor layer;

c) an n type semiconductor layer;

d) an i type semiconductor layer, comprising a multiple quantum well region comprising a number of III-nitride multiple quantum well layers of the same thickness and which are undoped or semi-insulating, between the p type and the n type semiconductor layers, and

e) a plurality of ohmic contacts, comprising metal alloys deposited on the surfaces of both said p type semiconductor layer and said n type semiconductor layer.

2. (Original) The device of claim 1, wherein said p type semiconductor layer comprises one or a plurality of layers selected from the group consisting of:

a) a single semiconductor layer of III-nitride materials;

b) a single semiconductor layer of a semiconductor material with a lattice matched to III-nitride materials; and

c) multiple layers of III-nitride materials.

3. (Original) The device of claim 2, wherein in (c), the number of layers of III-nitride materials is from 2 to 1000.

4. (Original) The device of claim 1, wherein said n type semiconductor layer comprises one or a plurality of layers selected from the group consisting of:

a) a single semiconductor layer of III-nitride materials; and

b) multiple layers of III-nitride materials.

5. (Original) The device of claim 4, wherein in (b), the number of layers of III-nitride materials is from 2 to 1000.

6. (Original) The device of claim 1, wherein said p type semiconductor layer has:

a) a doping level for reaching a hole concentration of at least $1x10^{18}$ cm^{-3}; and

b) a thickness of from one hundred nanometers to ten micrometers.

7. (Original) The device of claim 1, wherein said n type semiconductor layer has:

a) a doping level for reaching an electron concentration of at least $1x10^{18}$ cm^{-3}; and

b) a thickness of from one hundred nanometers to ten micrometers.

8. (Original) The device of claim 1, wherein said i type semiconductor layer is an active region of the device.

9. (Original) The device of claim 1, wherein said i type semiconductor layer comprises multiple quantum well layers of periodically grown units, and wherein each unit comprises one barrier layer and one adjacent well layer.

10. (Original) The device of claim 9, wherein said barrier layer and well layer are thin films of III-nitride materials.

11. (Original) The device of claim 9, wherein said barrier layer has a larger electronic band gap than said well layer.

12. (Original) The device of claim 9, wherein there are a number of units comprising alternating layers of barriers and wells.

13. (Original) The device of claim 9, wherein all barrier layers are made of the same III-nitride material and have the same thickness.

14. (Currently Amended) The device of claim 9, wherein all well layers are made of the same III-nitride material ~~and have the same thickness~~.

15. (Original) The device of claim 9, wherein the thicknesses of both said well layers and said barrier layers are from 1 nanometer to 100 nanometers.

16. (Original) The device of claim 9, wherein the III-nitride materials comprise group III elements of a predetermined mole fraction of group III element, such that the mole fractions of the group III elements and the thicknesses of said well layers and said barrier layers are specified so that conduction band offset between said well layers and said barrier layers is sufficiently large to produce at least two electron engine states in said well layers, wherein energy positions of said at least two electron engine states are theoretically determined by the effective mass equation, $[-\frac{\hbar^2}{2m^*}\nabla^2 + V(z)]F(z) = E_n F(z)$, where $\hbar$ is the reduced Planck constant, m* is the electron effective mass, V(z) is the electron potential along the material growth direction, F(z) is the effective-mass envelope function of electrons, and E_n is the energy of electrons at the n^{th} energy level in the quantum wells.

17. (Original) The device of claim 9, wherein said well layers and said barrier layers are semi-insulating.

18. (Original) The device of claim 9, wherein the number of units is from 3 to 1000.

19. (Original) The device of claim 1, wherein said III-nitride multiple quantum well layers are alternatively:

a) polar, with polarization extending from said p semiconductor layer to said n layer; and

b) non-polar.

20. (Original) The device of claim 1, wherein said III-nitride semiconductor materials comprise compounds selected from the group consisting of binary, ternary and quaternary alloyed compounds of nitrogen and at least one group III element selected from the group consisting of gallium, aluminum, and indium, and where the mole fraction of said group III elements in the compounds is in the range from 0 to 1.

21. (Original) A method of operating the device of claim 1 in a sequential resonant tunneling condition, by applying a predetermined working bias between metal contacts on a surface of the p type semiconductor layer and metal contacts on a surface of the n type semiconductor layer, such that said working bias produces an electron potential drop from the p type semiconductor layer to the n type semiconductor layer.

22. (Original) A method of operating the device of claim 1 in a sequential resonant tunneling condition, by applying a predetermined working bias between metal contacts on a surface of the p type semiconductor layer and metal contacts on a surface of the n type semiconductor layer, such that said working bias produces a near constant electric field in the multiple quantum well region and raises the energy state of a ground state in each well layer to the same level as the energy state of a first excitation state in the adjoining well layer.

23. (Original) A method of operating the device of claim 1 in a sequential resonant tunneling condition, by applying a predetermined working bias between metal contacts on a surface of the p type semiconductor layer and metal contacts on a surface of the n type semiconductor layer, such that said working bias produces photo-generated carriers that are transported by sequential resonant tunneling through the multiple quantum well region.

24. (Original) A method of operating the device of claim 1 in a sequential resonant tunneling condition, by applying a predetermined working bias between metal contacts on a

surface of the p type semiconductor layer and metal contacts on a surface of the n type semiconductor layer, such that said working bias is capable of being experimentally determined by measuring a current-voltage profile of the device, and such that a peak electrical current exists at the working bias.

25. (Original) A method of operating the device of claim 1 in a sequential resonant tunneling condition, by applying a predetermined working bias between metal contacts on a surface of the p type semiconductor layer and metal contacts on a surface of the n type semiconductor layer, such that said working bias is adjustable under high power illumination and at different temperatures.

26. (Original) Use of the device of claim 20 as a photodetector for producing photovoltaic signals, including electrical current and voltage signals, that are generated by external illuminating light.

27. (Original) The device of claim 20, wherein absorbing illumination strikes said device alternatively from a back side of said device and a front side of said device.

28. (Original) The device of claim 20, further comprising a window layer comprised alternatively of a p type semiconductor layer and an n type semiconductor layer, and further such that at least one of the following conditions applies with respect to said window layer:

a) said window layer has an electronic bandgap larger than the energy difference between the ground engine states of electrons and holes in the i semiconductor layer, such that energy positions of said engine states are theoretically determined by the effective mass equation

$$[-\frac{\hbar^2}{2m^*}\nabla^2 + V(z)]F(z) = E_n F(z) \quad ,$$

where $\hbar$ is the reduced Planck constant, m* is the electron effective mass, V(z) is the electron potential along the material growth direction, F(z) is the effective-mass envelope

function of electrons, and E_n is the energy of electrons at the n^{th} energy level in the quantum wells; and

b) said window layer is positioned close to the illuminating side of the device.

29. (Original) The device of claim 28, for use as a photodetector having a band spectral photo-response in a wavelength range from a short cutoff wavelength to a long cutoff wavelength, wherein:

a) said short cutoff wavelength in the range of 200 nm – 630 nm is induced by interband optical absorption of said window layer; and

b) said long cutoff wavelength in the range of 200 nm – 630 nm is induced by interband optical absorption of said i type semiconductor layer.

30. (Original) The device of claim 20, operating as an optically pumped infrared emitter in a sequential resonant tunneling condition, wherein, at least one of the following conditions applies with respect to said infrared emitter:

a) said infrared emitter emits infrared photons created by relaxation of photogenerated electrons from a first excited state to a ground state in the quantum wells, where the energy positions from the first excited states to the ground states are theoretically determined by the effective mass equation

$$[-\frac{\hbar^2}{2m^*}\nabla^2 + V(z)]F(z) = E_n F(z) \quad ,$$

where $\hbar$ is the reduced Planck constant, m* is the electron effective mass, V(z) is the electron potential along the material growth direction, F(z) is the effective-mass envelope function of electrons, and E_n is the energy of electrons at the n^{th} energy level in the quantum wells;

b) infrared photons emitted by said infrared emitter have an energy in the range of 20 meV to 1.3 eV, with said energy being equal to an energy difference between the first excited state and the ground state in the multiple quantum wells within the device; and

c) said infrared emitter emits an output of M infrared photons for each incident photon going through N quantum wells, where $M \leq N$.

31. (Original) A sequential resonant tunneling device for back-side illumination, comprising an alternating semiconductor layer structure as follows:

	Material	Thickness (nm)	Dopant	Doping level
	c-plane (0001) sapphire substrate	Not limited	Not limited	Not limited
	AlN	10	un-doped	0
	$Al_{0.2}Ga_{0.8}N$	1000	silicon	$1x10^{18}$ cm^{-3}
	$Al_{0.27}Ga_{0.73}N$	5	undoped	0
	GaN	4	undoped	0
QW unit, 30 QW units	$Al_{0.27}Ga_{0.73}N$	7	undoped	0
	GaN	4	undoped	0
	⋮	⋮	⋮	⋮
	$Al_{0.27}Ga_{0.73}N$	7	undoped	0
	GaN	4	undoped	0
	$Al_{0.27}Ga_{0.73}N$	5	undoped	0
	GaN	300	magnesium	$1x10^{18}$ cm^{-3}

32. (Original) The sequential resonant tunneling device according to claim 31, further comprising metal contacts on surfaces of n and p type semiconductors.

33. (Original) A sequential resonant tunneling device for front-side illumination, comprising a multi-layered semiconductor structure, as follows:

	Material	Thickness (nm)	Dopant	Doping level
	c-plane (0001) sapphire substrate	Not limited	Not limited	Not limited
	AlN	10	Undoped	0
	GaN	1000	Silicon	1x10^{18} cm^{-3}
	$Al_{0.25}Ga_{0.75}N$	5	Undoped	0
	GaN	4	Undoped	0
QW unit A	$Al_{0.25}Ga_{0.75}N$	7	Undoped	0
	GaN	4	Undoped	0
30 periods QW unit A	⋮	⋮	⋮	⋮
	$Al_{0.27}Ga_{0.73}N$	7	Undoped	0
	GaN	4	Undoped	0
QW unit B	$Al_{0.25}Ga_{0.75}N$	4	magnesium	1x10^{18} cm^{-3}
	$Al_{0.33}Ga_{0.67}N$	4	magnesium	1x10^{18} cm^{-3}
25 periods QW unit B	⋮	⋮	⋮	⋮
	$Al_{0.25}Ga_{0.75}N$	4	magnesium	1x10^{18} cm^{-3}
	$Al_{0.33}Ga_{0.67}N$	4	magnesium	1x10^{18} cm^{-3}
	GaN	10	magnesium	1x10^{18} cm^{-3}

34. (Original) The sequential resonant tunneling device according to claim 33, further comprising metal contacts on surfaces of n and p type semiconductors.

35. (Original) A sequential resonant tunneling device for front-side illumination comprising a multilayered semiconductor structure as follows:

	Material	Thickness (nm)	Dopant	Doping level
	6H-SiC substrate	Not limited	p-type	$1x10^{18}$ cm^{-3}
	AlN	10	un-doped	0
	$Al_{0.27}Ga_{0.73}N$	5	Undoped	0
	GaN	4	Undoped	0
QW unit	$Al_{0.27}Ga_{0.73}N$	7	Undoped	0
	GaN	4	Undoped	0
30 periods QW units	⋮	⋮	⋮	⋮
	$Al_{0.27}Ga_{0.73}N$	7	Undoped	0
	GaN	4	Undoped	0
	$Al_{0.27}Ga_{0.73}N$	5	Undoped	0
	$Al_{0.2}Ga_{0.8}N$	1000	Silicon	$1x10^{18}$ cm^{-3}
	GaN	10	Silicon	$1x10^{18}$ cm^{-3}

36. (Original) The sequential resonant tunneling device according to claim 35, further comprising metal contacts on surfaces of n and p type semiconductors.

37. (New) The device of claim 20, wherein said III-nitride semiconductor material is GaN, InN, AlGaN, InGaN, or InAlGaN.